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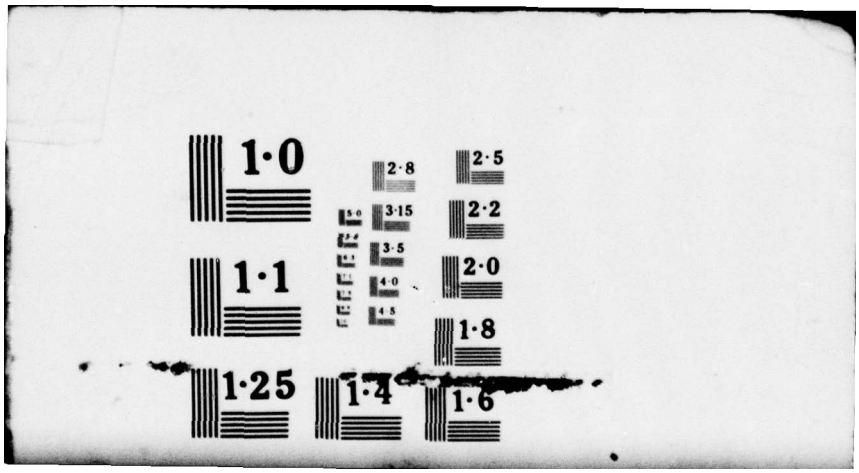
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NPRDC TR 79-25

July 1979

HYBRID JOB PERFORMANCE AID TECHNOLOGY DEFINITION

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Hybrid aids and enriched hybrid aids were evaluated. Concern focused on (1) whether Navy technicians would rely more heavily on the new aid forms as compared to conventional aids and (2) whether technicians would experience any learning enhancement as a result of using the new aid forms. (over)

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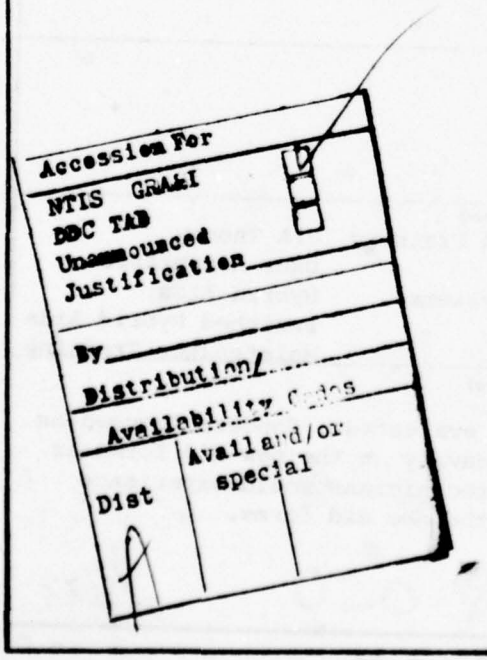
20. ABSTRACT (Continued)

The evaluation comprised a pilot study and the collection of expert and user opinion data. The experimental results and opinion data were used as the basis for selecting the most promising enriched hybrid aids for more rigorous testing.



FOREWORD

This research and development was conducted in response to Navy Decision Coordinating Paper, Performance Aids Test and Evaluation (NDCP-Z0828-PN), under the sponsorship of the Deputy Chief of Naval Operations (OP-01). The objectives of the NDCP are to define the state of the art in Job Performance Aids (JPA) technology, to develop a conceptual model for an integrated JPA-based personnel system including cost benefits and trade-off analysis, to test the JPA concept, and to quantify performance increments and cost benefits obtainable for various applications.

The Performance Aids Test and Evaluation project is based on the premise that current Navy personnel problems have their roots in the personnel system itself and therefore can best be addressed through a total "systems approach." Therefore, an Integrated Personnel Systems Approach (IPSA) was devised which is based on joint consideration of training design, JPA design, job design, career structures, advancement channels, incentives, and the quality and quantity of personnel resources available. Coupled with a cost trade-off model, IPSA is being employed to evolve a new personnel system concept entitled Enlisted Personnel Individualized Career System, or "EPICS."

The effort described in this report evaluated the potential that some unique forms of performance aids have for an integrated JPA-based personnel system. The performance aids evaluated in this project are referred to as hybrid aids and enriched hybrid aids. In evaluating both types, concern focused on: (1) whether Navy technicians would rely more heavily on the new aid forms as compared to conventional aids, and (2) whether technicians would experience any learning enhancement as a result of the new aid forms. The evaluation comprised a pilot study and the collection of expert and user opinion data. The experimental results and opinion data were used as the basis for selecting the most promising enriched hybrid aids for more rigorous testing.

This is the fifth in a series of reports dealing with the NDCP. The first, NPRDC TR 77-3, included seven papers assessing the state of the art in JPA technology. The second, NPRDC TN 78-6, described a preliminary attempt to define an enlisted personnel system concept, with major emphasis on the use of job performance aiding. The third, NPRDC TR 78-26, dealt with the systematic review and organization of existing JPA techniques, related research data, and various applicable principles and concepts. The fourth, NPRDC TN 79-1, is a preliminary attempt to define a JPA selection algorithm for an Integrated Personnel

System (IPS). Subsequent reports will deal with a series of tasks involving the development of an experimental IPS that can be implemented and evaluated in an operational setting.

The technical monitor was Dr. Robert J. Smillie.

Donald F. Parker
Commanding Officer

SUMMARY

Problem

Research has shown job performance aids (JPAs) to be a cost-effective means of facilitating performance of maintenance technicians, especially technicians with little on-the-job experience. As a major component of a Navy personnel system, however, JPAs must provide the JPA user with career support. The current use of JPA technology does not provide the user with total-career support.

Objective

The objective of this effort was to conceptualize and evaluate JPA candidates (troubleshooting) for an expanded role that:

1. Results in early productivity by inexperienced technicians, despite minimum "front end" training.

2. Allows JPAs to be usable at all stages of a technician's career, not merely in the initial stages.

3. Results in or encourages the learning of knowledge required to qualify for career milestones.

Approach

The concepts of "hybrid aids" and "enriched aids" were investigated to determine their applicability to the objectives for JPAs. Through pilot testing, the hybrid aids were evaluated in terms of their capacity for allowing a technician to graduate, over a period of use, from a reliance on the "directive JPA" to the more independent, decision-making mode of the "deductive JPA." Expert judgment determined which of the enriched JPAs were effective in imparting significant kinds of incidental learning during transition from the instruction-following to the autonomous mode.

Findings

1. The use of hybrid JPAs for troubleshooting tasks appears feasible.

2. Enrichment appears feasible when used to enhance the transition effect of hybridization.

3. Enrichment appears feasible when used to convey career-relevant knowledge about the hardware and the operational principles that underlie classes of hardware.

Recommendations

1. Findings in this study were derived from (a) pilot testing (e.g., small sample size, nonrepresentative subjects) and (b) opinions of experts in both JPA research and JPA use. Before conducting any extensive field test of the enriched hybrid JPA, a more rigorous demonstration of its feasibility is required.

2. Analytical work is required toward application of the enriched, hybrid JPAs investigated in this project. Key features needing further definition include format considerations, exposure control, and interfaces with other features of the personnel system (e.g., training, performance assessment).

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INTRODUCTION

Problem

Job performance aid (JPA) research in the past has concentrated on two basic JPA formats--directive (e.g., fully proceduralized JPAs) and deductive (e.g., schematics). Directive formats allow apprentice technicians (novices) to perform on the job without extensive training and experience, while deductive formats allow system technicians (fully trained and experienced individuals) to continue in the job without relying on memory alone. Neither format is totally satisfactory for the individual at an intermediate level of skill (e.g., subsystem technician). The deductive JPAs are still too complicated, and the directive JPAs are inadequate and too time consuming for complex troubleshooting. Therefore, an innovative JPA format is needed to bridge the gap between apprentice and experienced technicians.

Purpose

The purpose of the present project was to conceptualize those JPA candidates (troubleshooting) for subsystem technicians that bridge the gap. In addition, the candidate JPA concepts were evaluated to select those candidates that warrant additional verification testing.

The development of this innovative JPA will occur in three stages:

1. Conceptualization and evaluation (present project).

2. Verification testing (JPAs independent of other elements of the personnel system).

3. Shipboard demonstration (JPAs integrated with the other elements of the personnel system).

Background

The present project is part of an overall program the objective of which is to design and demonstrate the benefits of a JPA-based Integrated Personnel System (IPS) (Blanchard & Laabs, 1978). The characteristics of the JPAs in the IPS are:

1. Use of JPAs results in early productivity by inexperienced technicians despite minimum front-end training.

2. Use of JPAs is high at all stages of a technician's career, not merely in the initial stages.

3. Use of JPAs results in or encourages the learning of knowledge required to qualify for career milestones.

THE EVOLUTION OF JOB PERFORMANCE AIDS

Proceduralized Aids

Designed to support maintenance, the classical Technical Manual (TM) contains descriptions of the hardware and of the procedures necessary to operate and maintain the hardware. Traditionally, technicians used the TM to gain an understanding of the system to supplement or substitute for the relatively brief TM procedures. As systems grew more complex, however, this approach became very time-consuming and resource-intensive. Extensive front-end training was necessary for a new technician to understand a system. Even when equipped with this training, new technicians required lengthy apprenticeships on the job before they were capable of independent maintenance performance.

In the late 1950s, the Air Force initiated research (Hoehn & Lumsdaine, 1958) designed to emphasize the procedural portions of the TM. The intention of this early research was to find an approach that shortened both the apprenticeship period and the front-end training. Experiments using proceduralized aids gave promising results, and eventually led to field demonstrations of what have become known as job performance aids (JPAs). The best known of these quite successful demonstrations were PIMO--Presentation of Information for Maintenance and Operations (Goff, Schlesinger, & Parlog, 1969) and AMSAS--Advanced Manpower Concepts for Sea-Based Aviation Systems (Post & Brooks, 1970).

In spite of these apparent successes, the military did not adopt the JPA form of TM. JPA research continued on a small scale until 1974, when Malehorne (1975) formulated a major advance in JPA technology. Malehorne proposed that JPAs would not be accepted until they were shown to be capable of working on a continuing basis with the Navy's current personnel system. The following is one of several examples he presented to illustrate the impracticality of existing JPA technology:

> Advocates claim that the use of JPAs will allow extensive reductions in theory-based, front end training without adversely affecting the early productive labor obtainable from a new technician. However, the advocates failed to recognize that reducing the theory-based training also seriously erodes the technician's ability to pass advancement in Rate exams which, at the present time, demand extensive knowledge of theory. (p. 142)

In addition to these types of JPA concerns, questions arose about the technician's acceptance of the proceduralized form of documentation. It was felt that technicians would quickly resent (and therefore fail to use) the proceduralized JPA if it were the only form of documentation available. In other words, some changes would have to be made in the JPA to integrate it into the larger Personnel System and to enhance its acceptability. One JPA approach, called "hybridizing," seemed to have the potential to address at least some of these needs.

History of the Hybrid Aid

Concept

The hybrid aid was conceived in projects sponsored by the Naval Air Systems Command (Post & Price, 1972; Post & Price, 1973). The concept emerged from a review of the types of troubleshooting aids included in 26 information presentation techniques. This review concluded that the terms "directive" or "deductive"[1] could characterize all the troubleshooting approaches used by the presentation techniques. Table 1, which was adapted from Post and Price (1973), summarizes these characterizations.

Concerned with improving what they perceived to be poor aid acceptance, Post and Price examined the use of directive and deductive aid forms against three criteria drawn from the literature on work and job satisfaction. As researched by Ford (1969), these criteria appeared to be particularly relevant to JPA acceptance:

1. Opportunity to Learn. A good job (job aid) is one in which the worker is afforded opportunities to learn skills or knowledge relevant to career advancement.

2. Challenge. Workers tend to be satisfied with jobs (job aids) that, over a period of time, offer challenge. The challenge can occur in the form of quantity or complexity of the tasks included in the job.

3. Meaningfulness of the Work. Workers tend to feel satisfied when they have a significant role in performing tasks that they perceive to be critical in the output or goal of their organization.

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[1] The term deductive refers to those aid forms that describe the system (e.g., functional diagrams or electronic schematics). The term deductive is indicative of the behavior required of the troubleshooter; that is, he had to understand the relationships between systems, functions, and signal flows in order to deduce the correct troubleshooting procedure.

Table 1

Overview of Existing Aid Techniques
(Adapted from Post & Price, Development of optimum performance aids for troubleshooting, 1973.)

Existing Maintenance Data Techniques	Directive	Deductive	Existing Maintenance Data Techniques	Directive	Deductive
1. A New Look in Commercial Overhaul Manuals[a]	X	X	14. Rapid Automated Problem Identification Data System (RAPIDS)	X	
2. Automated Technical Orders Maintenance Sequences (ATOMS)	X		15. Symbolic Integrated Maintenance Manuals (SIMM)		X
3. Binary Fault Isolation Chart (BIFAC)	X		16. Transistor Radio Automatic Circuit Evaluator (TRACE)	(Template; Not Applicable)	
4. Data Aids for Training Operations and Maintenance (DATOMS)		X	17. Videosonic	(Media only)	
5. Electrocular	(Media only)		18. Weapon System Maintenance Action Center (WSMAC)	X	
6. Forecast		X	19. BAMAGAT		
7. Graphically Proceduralized Aids for Maintenance (GPAMS)	X		20. Integrated Maintenance Concept (IMC)	See 15 above	
8. Maintenance and Training in Complex Equipment (MAINTRAIN)	X	X	21. Fault Isolation by Semi-Automatic Techniques (FIST)	Automatic Testing to the Between-Stage Level – No Coverage of Within Stage Troubleshooting	
9. Miniature Microviewers	(Media only)		22. Automatic Diagnostic Maintenance Information Retrieval (ADMIRE)	X	
10. MINIDATA	(Media only)		23. Fully Proceduralized	X	
11. Presentation of Information for Maintenance and Operations (PIMO)	X	X	24. Job Train	X	
12. Profile Cards	Insufficient Information to Permit Analysis		25. Maintenance Data System (MDS)	X	X
13. Pyramid Diagram (PYRAGRAM)		X	26. HAWK Radar Mechanic		X

[a] Entries in both columns mean that the data technique uses both the directive and deductive forms of troubleshooting aids.

Table 2 summarizes how the use of deductive and directive JPAs fared against these job satisfaction criteria. As shown, an examination was conducted for both experienced and inexperienced technicians. The conclusion of this analysis was that the deductive JPA is the approach suitable for experienced technicians, since it allows them to practice a valued skill that sets them apart from their less-experienced colleagues. On the other hand, the directive JPA appears to benefit the inexperienced technicians, since it allows them to participate in work that would be beyond their capability under conventional circumstances. Accordingly, if a JPA is to be acceptable to both populations, it should involve some combination, or hybrid of the deductive and directive aid forms.

Use of Hybrid JPA

Scenario for Use. Figure 1 illustrates the directive and deductive elements of a hybrid aid. The directive element (presented alongside the deductive element) would provide the inexperienced technician with guidance to do meaningful work that would be beyond his capability with conventional TMs. The hybrid users would be briefed on the objective of transitioning gradually from reliance on the directive element to doing the same task more autonomously by referring only to the deductive element. This transition is facilitated by the side-by-side presentation of the two elements as well as by their design. For example, both use the same signal names and test-point nomenclature, and both cover the same portion of the hardware. This transition offers the JPA user a continuing challenge. It also offers an opportunity to learn career-relevant knowledge, since mastering the use of the deductive aid ensures mastery of many of the content items required to pass the Personnel Qualification System (PQS).[2]

The strategy underlying the hybrid is that, over a series of performances, the technician will become more and more familiar with the deductive element until he feels ready to troubleshoot using only the deductive element. Should he encounter difficulty in using the deductive aid, he can refer back to the directive element for guidance on how to proceed or for assurance of the correct response (i.e., does his deductive-aid solution agree with the directive-aid solution?).

When Introduced. It is appropriate at this point to discuss the stage in the technician's career at which he is expected to be using this form of JPA. We assume that a new

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[2]The PQS is the means by which technicians are qualified to stand watch, which is, in turn, a prerequisite for taking the advancement in Rate exams.

Table 2

Summary of Assessing Directive and Deductive Aid Forms Against Selected Job Satisfaction Criteria

Job Satisfaction Criteria	Inexperienced Users		Experienced Users	
	Directive	Deductive	Directive	Deductive
1. Opportunity to learn career-relevant skills	Opportunities are primarily memorization of rote procedures (e.g., test point and part location, turn on-off procedures). Opportunities to learn more career-relevant items (system operation, troubleshooting methods) are limited.	Opportunities to learn system operating principles and methods of troubleshooting are present but of such a complex nature as to require lengthy learning cycles and senior tutors.	Continued use of the directive aid offers only the opportunity to become more proficient in its use (e.g., quicker application).	Each "new" failure represents an opportunity to learn new aspects of the system such as component dependencies, as well as practice in troubleshooting methods.
2. Meaningful work	Good results, at least initially, because the aid permits the technician to do work that would otherwise be beyond his capability.	Poor results in that the technician is reduced to observation and menial support chores during his lengthy apprenticeship.	Continued use of the directive aid represents rote performance with no true understanding of the logic or reasons behind each sequence.	Good meaning in that the technician is required to develop his own strategy and procedures for each use of the aid.
3. Challenge	Some initial challenge which diminishes rapidly because the aid is designed to be mastered in the first usage.	Substantial challenge requiring large investments of time and effort from both the learner and his mentor.	No challenge resulting in a boring job which becomes worse with each application of the aid.	Good challenge for a considerable period of time. Eventually, the use of the aid as a "guide" is replaced by its use as a reference and consequently the work retains its challenge.

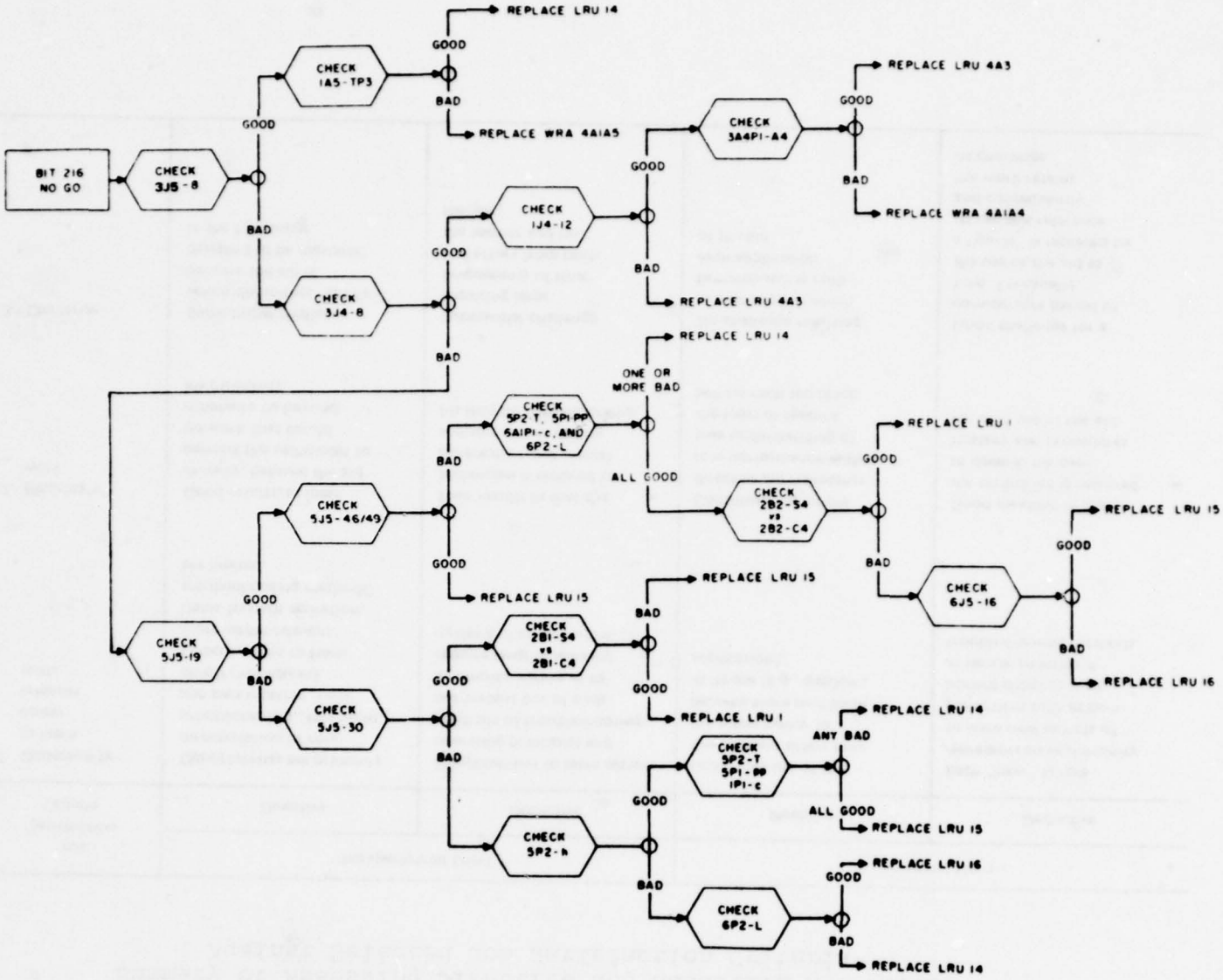

Figure 1a. Illustration of a hybrid aid (directive element).

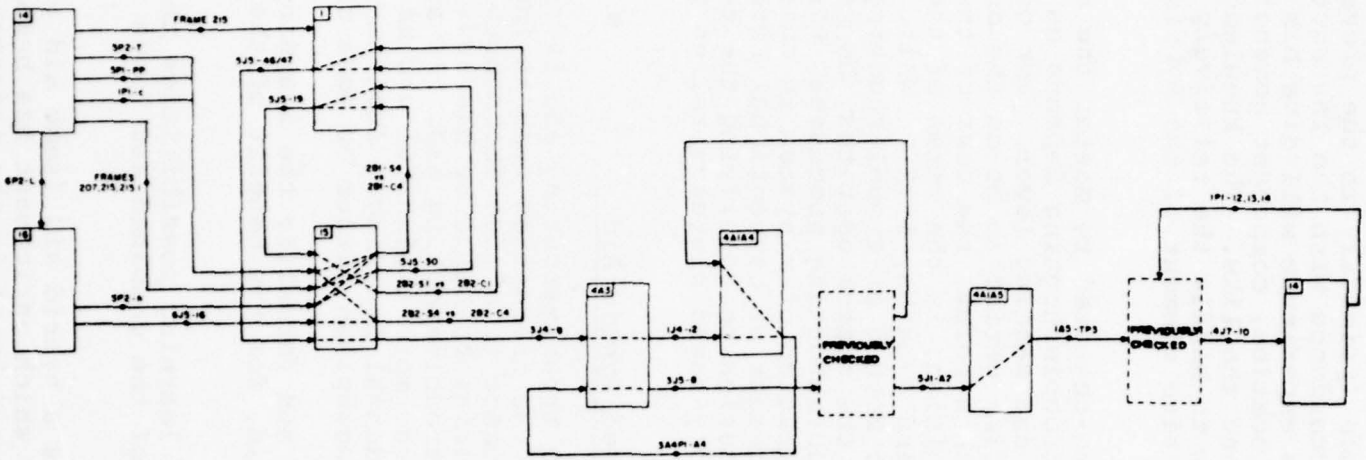

Figure 1b. Illustration of a hybrid aid (deductive element).

technician's first year of duty would have him performing non-troubleshooting maintenance (primarily in the preventive maintenance domain) in accordance with the instructions of a fully proceduralized JPA. This experience will give him considerable knowledge of test point location, component nomenclature, set-up and turn-on procedures, and the like. The knowledge gained in this stage will equip him to handle the relatively "austere" instructions of the directive element of the hybrid shown in Figure 1.

The length of time required to master the simple input-output process of troubleshooting depends on the unit's troubleshooting workload and manning level. For our purposes, we are considering this time period to be on the order of 6 months to a year. At this point, the user of the hybrid aid is a Skill Level II technician, in the terms of the Integrated Personnel System (Blanchard & Laabs, 1978). While he has mastered the simple logic method of troubleshooting and has learned something of how the system operates, he knows nothing of the more advanced troubleshooting processes, nor of the theory underlying the operation of a system in this class, which is a major content requirement of conventional Rate advancement exams. The JPA's contribution to qualifying the technicians on these more advanced, theory-based plateaus relies on the use of "enriched" hybrid JPAs.

Concept of the Enriched Hybrid Aid

Use of the hybrid troubleshooting aid is expected to help the technician make the transition from an instruction-following mode of performance to a more autonomous mode. Then, he is required to make decisions based on his understanding of a simple-logic, deductive troubleshooting aid. In accomplishing the transition, some of the more insightful and motivated users may experience some incidental learning. Enrichment is introduced at this point to accomplish either or both of two purposes:

1. To explicate and formalize the learning opportunities inherent in the hybrid aid, for the benefit of the less insightful users.

2. To introduce learning possibilities that are related to but beyond the scope of the combined aid forms (e.g., theory-based learning).

Figure 2 presents a hybrid aid (same aid elements as appeared in Figure 1) in which enrichment has been added to the directive element. The enrichment is the information that appears in the brackets. As shown, the enrichment message explains the

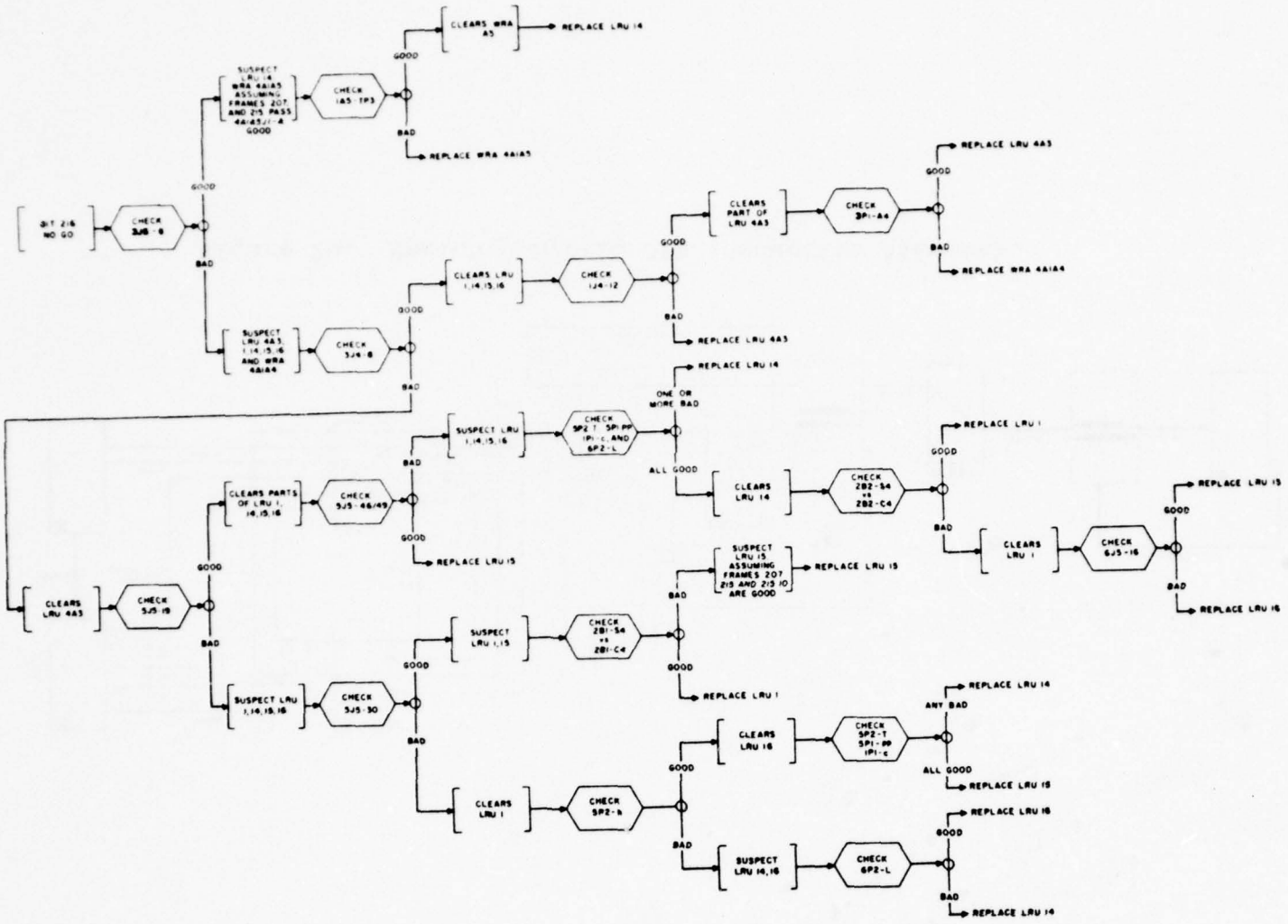

Figure 2a. Enriched hybrid JPA (directive element).

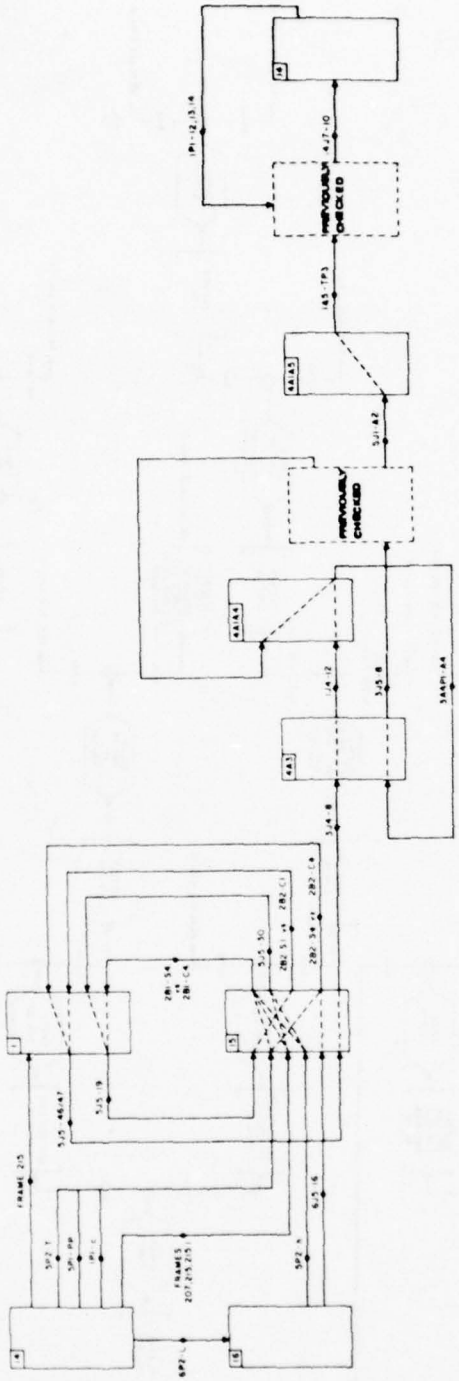

Figure 2b. Enriched hybrid JPA (deductive element).

troubleshooting progress represented by the preceeding check or test outcome. The explanations use the terminology of the deductive aid as an attention-directing device. In this example, the enrichment message is emphasizing a subtle possibility already present in the hybrid aid. Other illustrations will be presented later in which the enrichment information is related to but beyond the scope of the hybrid aid content.

The major features of the enrichment concept are summarized below:

1. It provides the user with information to explicate a subtle characteristic of the hybrid JPA, or one that is related to but beyond the content of the hybrid.

2. It uses the task/work situation to lend meaning to what might otherwise be perceived by the user as abstract material.

3. It motivates the user as a result of learning opportunities that are oriented to performance (e.g., to learn a simple logic troubleshooting method) or to knowledge (e.g., to learn more about this hardware or this class of hardware).

DEVELOPMENT OF THE HYBRID AND ENRICHED HYBRID FORMS OF JPA

The preceding section of this report introduced the concepts of the hybrid job performance aid (HJPA) and enriched hybrid job performance aid (EHJPA). The aid form used to illustrate these discussions was actually one of the several possibilities available for implementing these concepts. The following discussions define the concepts more specifically and show candidate approaches to hybridization and to enrichment. Subsequent experimentation will evaluate these candidate approaches to determine those amenable to additional development and test.

Development of HJPA Candidates

The concept of the hybrid JPA is a promising candidate for inclusion in the Integrated Personnel System (IPS) because it:

1. Permits inexperienced technicians to perform complex troubleshooting without continuous supervision.

2. Allows postponement or redistribution of the theory-based training which, historically, has been given at the beginning of a new enlistee's career.

3. Has the potential to increase aid utilization in all stages of a technician's career.

Before these objectives can be pursued, the hybrid must be defined more precisely. Specifically, it is necessary to identify the population of directive and deductive formats. Using these formats, hybrids can be developed to verify that the formats are feasible, and to identify specific HJPA aspects for evaluation. These topics are discussed below.

Available Formats

Table 1 identified 26 presentation techniques that are, theoretically, available for use in developing hybrids. Results of more recent studies (Shriver & Hart, 1975; Booher, 1978) have expanded this list. At present, there are more than 100 presentation techniques that could be considered as potential hybrid aid elements. Clearly, this number of aid elements must be reduced to a more manageable size before the hybrid can be considered a practical part of the IPS.

The work of Post, Price, and Diffley (1976) provides a basis for extracting basic aid formats from the more than 100 presentation techniques. The extraction process relies on the

type of behavior required of the JPA user. The top of Figure 3 lists two fundamentally different types of behavior possible for troubleshooting tasks--instruction following and decision making. These behaviors are, in turn, divided into two subtypes, resulting in four different behaviors required of JPA users. A basic JPA format is matched to each different behavior, as shown at the bottom of Figure 3. These basic JPA formats were considered in the present study as the JPA elements that could be used or combined to form a hybrid JPA; for example, by combining a fully proceduralized JPA with a schematic. Before formal consideration, however, it was necessary to verify that each basic aid format had undergone sufficient field or laboratory testing to qualify as an integral part of the Integrated Personnel System.

JPA User Behaviors / Basic JPA Formats	Instruction Following		Decision Making	
	Procedure-following pure JPA	Procedure-following some memory	Simple Logic	Theory-based decisions
	Fully proceduralized job performance aid	Partially proceduralized job performance aid	Maintenance Dependency Chart (MDC), Functional flow logic diagram	Schematics

Figure 3. Basic aid formats and user behaviors.

Verification of Basic Aid Formats

The aid forms considered for hybridizing must be proven individually before they can be used in combination. This means that the basic aid forms to be considered for hybridization must have been verified through at least laboratory and preferably field test evaluations. Table 3 lists a key verification project for each of the five basic aid forms discussed in Available Formats. Thus, all five formats may be considered for hybridizing.

Table 3

Test Data Available to Verify Basic Aid Formats

Basic Aid Format	Test Data Reference
Fully Proceduralized JPAs	Potter & Thomas, 1976 (C-141)
Partially Proceduralized JPAs	Horn, 1973 (AWG-10)
Maintenance Dependency Charts	Horn, 1973 (AWG-10)
Functional Flow Logic Diagrams	Atchley & Lehr, 1964; Losee, et al., 1962
Schematics	Atchley & Lehr, 1964; Losee, et al., 1962

Identification of Specific HJPA Candidates

Figure 4 represents 10 hybrids that can be formed from the basic aid formats[3] being considered. Each numbered cell of Figure 4 represents a possible (not necessarily desirable) hybrid. For example, cell 6 represents a hybrid formed by combining the partially proceduralized job performance aid (PPJPA) with the functional flow logic diagram (FFLD).

The aid forms listed in the left-hand column represent the element the user would rely on for his initial performance attempts. The aid forms shown in the header of Figure 4 are those to which the user would progress.

Basic Aid Formats	Basic Aid Formats: FPJPA	PPJPA	MDC	FFLD	Schematic
FPJPA		1[a]	2	3	4
PPJPA			5	6	7
MDC				8	9
FFLD					10
Schematic					

[a]Cell entries refer to transition from row heading to column heading.

Figure 4. Representation of hybrid possibilities arising out of five basic aid formats.

At this stage of the hybrid aid development, there are ten candidate hybrids. The candidates were evaluated to determine which ones to field test.

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[3]The MDC and the FFLD require the same behavior of the JPA user. The physical features of these aid forms, however, are so different that each was retained as a separate aid type.

Development of EHJPA Candidates

Specific EHJPA candidates were defined by two dimensions: (1) the type or purpose of the enrichment message, and (2) the means or format used to make the enrichment available to the user. Each of these dimensions is discussed below, followed by an identification of the EHJPA candidates they define.

Definition of Enrichment Types

By definition, the enrichment must relate to and possibly go beyond the content of the two elements of a hybrid JPA. On this basis, the present study identified three types of enrichment.

1. Transition--Any information designed to help the hybrid user transition from the directive to the deductive aid form.

2. System Understanding--Information about the operation of the hardware represented in the deductive aid of the hybrid.

3. Theory--Information about the operation of or principles underlying the class of equipment to which the present hardware belongs.

Delivery Formats

Research by the Navy (Smillie, 1978) identified three "formats" by which enrichment information can be made available to the user of a hybrid aid.

1. Interpretive--A format that provides the enrichment message as an integral part of the hybrid aid (i.e., on the same sheet of paper).

2. Basic Reference Cues--A technique whereby either or both of the hybrid elements may contain notes that refer the user to another source document (e.g., another maintenance manual or a Rate Training Manual).

3. Extension Training Reference Cues--A technique whereby either or both of the hybrid elements may contain notes which refer the user to a personalized training source available at the local level ("personalized" excludes local classroom activities; "local level" excludes formal, institutional training).

Identification of Specific EHJPA Candidates

Figure 5 combines the dimensions of enrichment type and delivery format into a matrix whose cells define the specific EHJPA concepts evaluated in this report. To illustrate, the enriched hybrid aid which appeared as Figure 2 in the enrichment concept discussion would be associated with cell #1 because the purpose of its enrichment message is to help the user to transition from directive to deductive modes of troubleshooting; and the enrichment message would appear as an integral part of one of the hybrid elements--in this case, the directive element.

These nine types of EHJPAs were evaluated to determine which offered the most promise to the Integrated Personnel System. The results of this evaluation are discussed in the next section.

	Delivery Formats		
Enrichment Types	Interpretive	Basic Reference Cues	Extension Training Reference Cues
Transition	1	2	3
System Understanding	4	5	6
Theory	7	8	9

Figure 5. Matrix to define EHJPA candidates.*

*Combinations of these nine types of EHJPAs are also possible. For example, types 1 and 4 and types 1, 4, and 5 are possible approaches to enrichment. However, the evaluation focused on the nine basic types.

EVALUATION OF THE HYBRID JPA AND ENRICHED HYBRID JPA CANDIDATES

Evaluation of the HJPA Candidates

The ten HJPA candidates were pared to two promising candidates through subject assessment. These candidates were then evaluated by pilot testing.

In the earlier discussion of the hybrid concept, Figure 4 used five basic aid formats to define ten hybrid possibilities. This figure is repeated here for convenience and appears as Figure 6. The ten hybrid possibilities were rated by project personnel for the purpose of eliminating those candidates that did not warrant further investigation. The rating criteria and outcomes are discussed below.

Basic Aid Formats	FPJPA	PPJPA	MDC	FFLD	Schematic
FPJPA		1[a]	2	3	4
PPJPA			5	6	7
MDC				8	9
FFLD					10
Schematic					

[a]Cell entries refer to transition from row heading to column heading.

Figure 6. Representation of hybrid possibilities arising out of five basic aid formats.

Rating Criteria

Two criteria were considered in assessing the ten hybrid aid candidates. A major objective of the hybrid is to foster early productivity in inexperienced, minimally trained technicians. Thus, one criterion used for assessing hybrid feasibility was the performance-fostering power of the directive element. Since

another objective of the hybrid concept is to focus on transitioning from one aid to another, the second criterion was the direction and ease of the transition. Table 4 lists these two criteria, along with the possible outcomes associated with each.

Table 4

HJPA Rating Criteria

Criteria	Outcome Possibilities
A. Performance-fostering power of the directive element	1. Stronger than necessary for the target population 2. Appropriate power for the target population 3. Insufficient power for the target population
B. Direction and ease of transition	4. Wrong type, merely rote learning, or learning within an aid type 5. Correct type; between aid forms, but not too large a transition 6. Too demanding; spans are too large or too complex

HJPA Rating Results

The six rating outcomes shown in Table 4 are assigned as appropriate to each of the HJPA candidates. These assignments are shown in Figure 7, along with a code that indicates whether the hybrid possibility is rejected (R) or considered feasible (F). Thus, R-1,4 indicates that the hybrid possibility is rejected because (1) the simpler element is stronger or more detailed than necessary for the target population and (4) the transition is too simple and of the wrong type.

The assumptions made in arriving at the outcomes shown in Figure 7 are listed below:

1. The HJPA is primarily an intermediate aid form, expected to be used by technicians newly qualified at this level.

2. During their novice work, technicians obtained substantial hardware geography familiarization (e.g., test point and component location) even though their assignments were confined to preventive and nontroubleshooting maintenance tasks.

3. Prior to assignment, technicians are given task-oriented training on test point location, test equipment and prime system setup, and test equipment and aid usage.

4. Technicians who use HJPAs are Category 3a[4] and above. Changes in this assumption would cause major shifts in the evaluation outcomes.

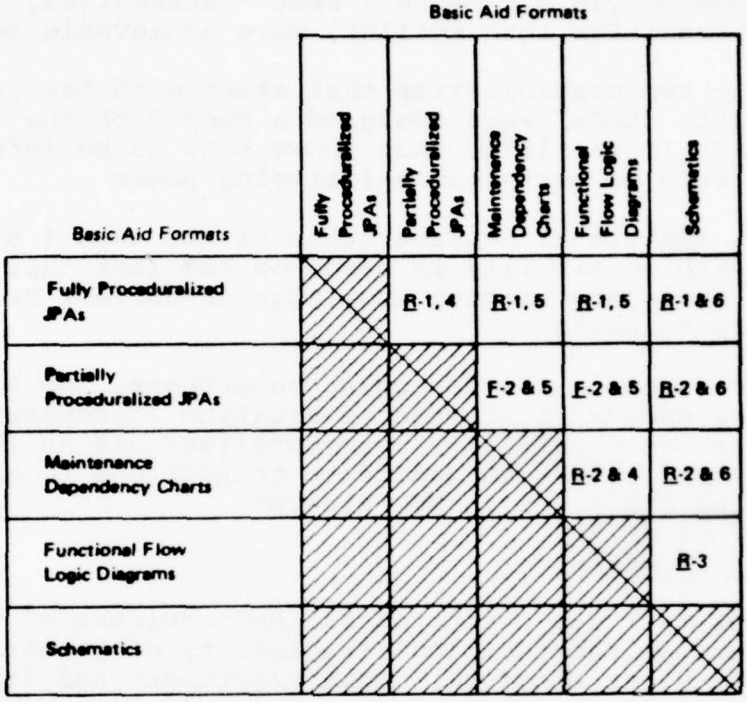

Figure 7. Results of applying rating criteria to 10 hybrid possibilities.

Observations about the rating results shown in Figure 7 are as follows:

1. The PPJPA → FFLD and the PPJPA → MDC appear to be the best candidates against the criteria used.

2. The code 1 assignments made to FPJPA possibilities are judgmental and based on all assumptions about the target population. Any changes in the assumptions could change the code 1 assignments.

3. The two code 4 assignments reflect an undesirable transition within a behavior type, as opposed to between behavior types.

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[4]Category 3a personnel are defined as those personnel having an average percentile score between 64 and 49 on the word knowledge, arithmetic reasoning, and spatial perception subtests of the Armed Services Vocational Aptitude Battery.

4. The code 6 assignments are less a rejection of the higher order deductive aid (schematics, system descriptions) and more a reflection of the incompleteness of the hybrid concept. For example, the two stage PPJPA → FFLD might well be expanded to a third stage to yield a PPJPA → FFLD → Schematics, thereby breaking the transition into smaller, more achievable segments.

5. The two possibilities that start with Maintenance Dependency Charts (MDCs) were assigned a code 2 on the basis of an experiment (Horn, 1973) that shows MDCs to be inferior to PPJPAs in terms of performance-fostering power.

6. An additional consideration of the code 4 assignments to the MDC → FFLD possibility is based on the fact that both aid forms require decisions without knowledge of correct response being available to users.

On the basis of the foregoing assessment, two HJPA candidates were chosen for further evaluation (discussed below). Both candidates use a partially proceduralized aid as the simpler, directive element. One HJPA candidate transitions to an FFLD element; and the other, to an MDC element.

Pilot Test of HJPAs

A pilot test was conducted on the survivors of the HJPA rating to determine the technical feasibility of transitioning from one to the other aid form. This experiment and its results are described below.

Test Design. The test design is presented in graphic form in Figure 8. A description of the treatments and a rationale for their arrangement is provided in the following section. The test design is set up to permit a comparison of improvement over trials for the three treatments. While the test is designed to show feasibility of the hybrid concept, it was felt that some useful comparisons would emerge with the addition of the enriched version of the hybrid.

Treatments	Sequence					
	Pretest	Learning Trials (4)				Post-Test
Hybrid (PPJPA/FFLD)	N = 14					→
Enriched Hybrid (EPPJPA/FFLD)	N = 14					→
Unenriched Hybrid (PPJPA/MDC)	N = 7					→

Figure 8. Design of HJPA experiment.

All subjects were briefed on the test materials and task operations. A test monitor was present during all trials so that misunderstandings could be resolved, if necessary.

The pretest was conducted using only the deductive element of the hybrid aid (Functional Flow Logic Diagram or Maintenance Dependency Chart). The learning trials were conducted using the various hybrid arrangements while the post-test employed, again, only the deductive aid. (The paradigm is that of standard transfer-of-training test procedures.) Subjects were given a 10-minute time limitation per task (trial).

Subjects. Two groups of subjects were used. Twenty-eight were undergraduate students at Northern Virginia (NOVA) Community College and seven were employees of BioTechnology, Inc. (BTI). The 28 students were randomly assigned to two equal-sized groups of 14 each. These two groups experienced the PPJPA/FFLD and the enriched PPJPA/FFLD conditions. For logistical reasons, all subjects in the unenriched PPJPA/MDC condition were BTI employees.

Task Characteristics. The tasks involved paper-and-pencil versions of electronic troubleshooting tasks. They were derived from the actual troubleshooting operations for the AWG-10 missile system. Each task was performed using the same hybrid aid. The variation between tasks was in the "correct answer"; that is, the component with the malfunction was different for each task. Each subject experienced the same task sequence, that is, the order of correct answer was the same throughout all conditions.

Description of Test Materials. PPJPA → FFLD. An EHJPA was added to the experiment to show the contribution made by the addition of an enrichment message. Figure 9a illustrates the enriched version of the partially proceduralized aid. Subjects assigned to the straight hybrid group performed with the aids shown in Figure 9a but without the information shown in the brackets, and subjects assigned to the enriched group, with the PPJPA shown in Figure 9a. Figure 9b shows the deductive aid used by subjects in both groups.

PPJPA → MDC. Figures 10a and 10b represent the PPJPA combined with the MDC as the deductive element of the HJPA. (Only the lower part of the MDC relates to the PPJPA shown.)

Pilot Test Results. The experiment used two performance measures: percent correct responses (accuracy) and delay, measured as seconds per test point. The findings are summarized in Figures 11 and 12. Regarding accuracy, the pretest results show similar percent correct scores for the three conditions. The enriched hybrid using a functional flow diagram gains most in the learning sequence, while the straight hybrid using an MDC does not show any accuracy improvements.

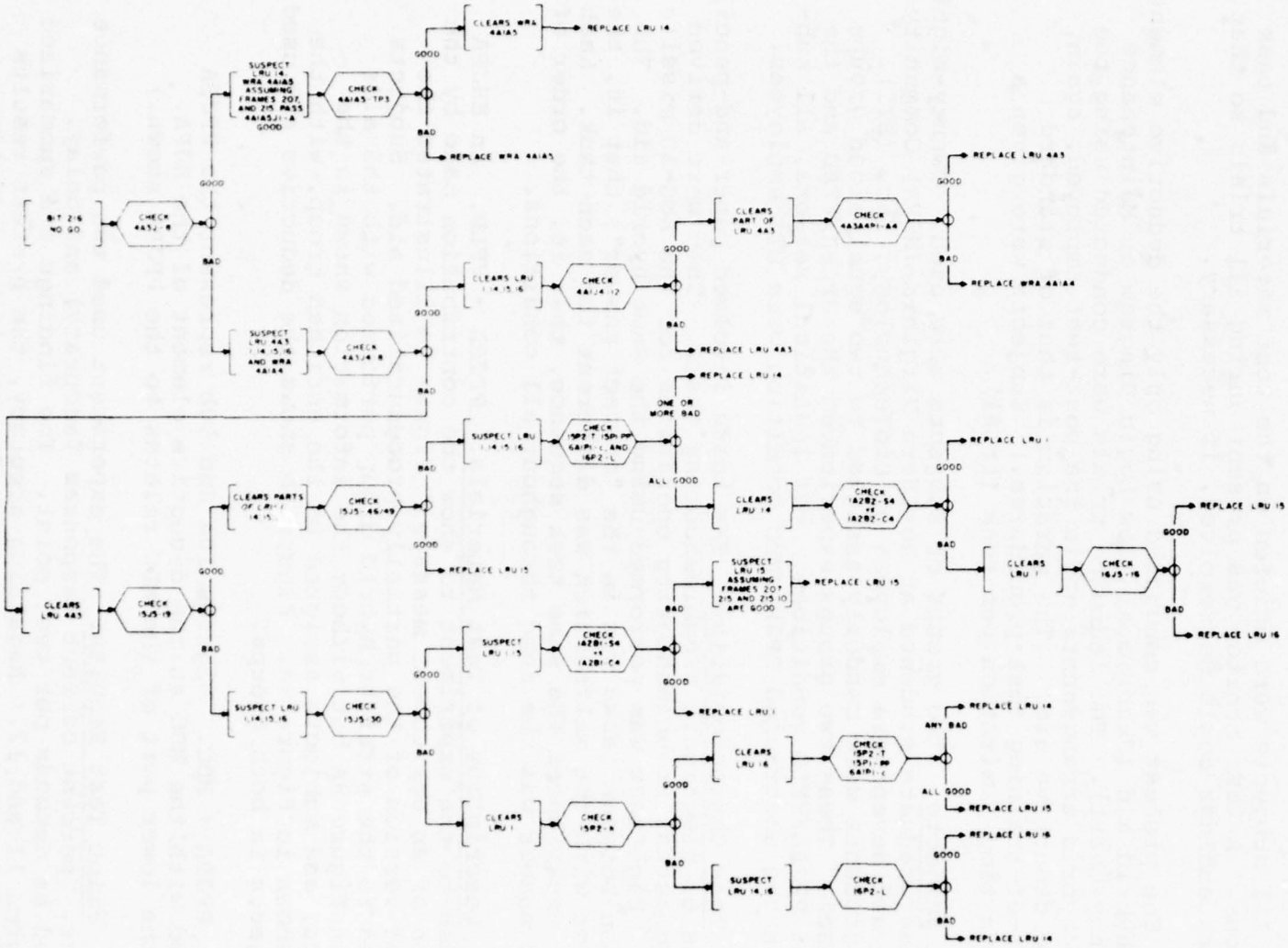
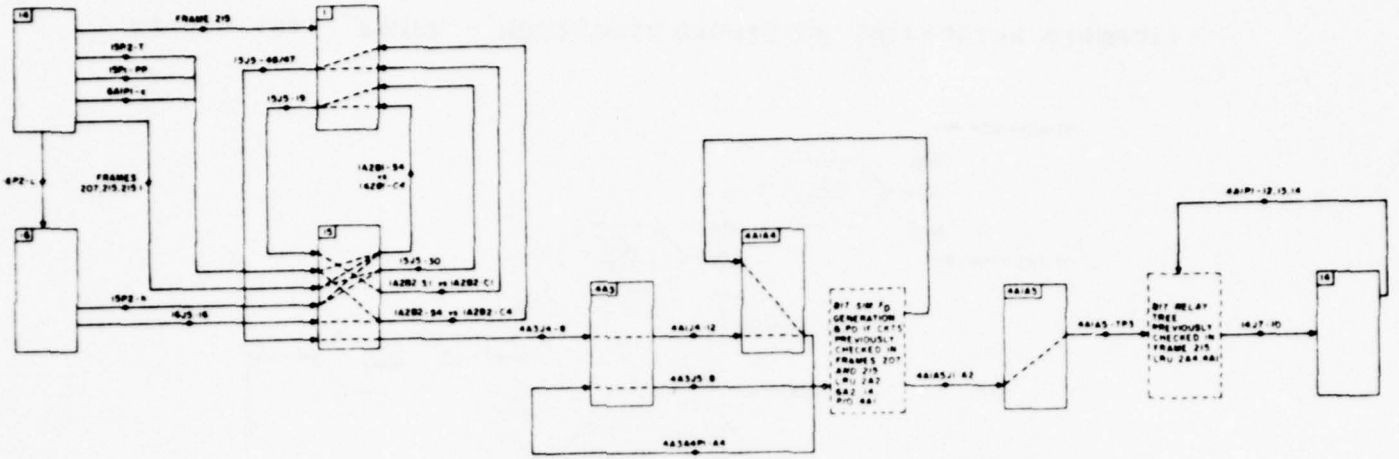


Figure 9a. Enriched hybrid JPA candidate (directive element).



TEST SPECIFICATIONS		
TEST POINT	SIGNAL	VALUE
1A2B1: B1 vs 1A2B1: C4		DYM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE (1) C4 BETWEEN 0.3 AND 10.5 VAC (2) B1 < 10.5 VAC IF C4 > 10.5 VAC (3) B1 > 0.3 VAC IF C4 < 0.3 VAC
1A2B1: B1 vs 1A2B1: C1		DYM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE (1) C1 BETWEEN 0.3 AND 0.3 VAC (2) B1 < 0.3 VAC IF C1 > 0.3 VAC (3) B1 > 0.3 VAC IF C1 < 0.3 VAC
1A2B2: B4 vs 1A2B2: C4		DYM REQUIRED TEST PASSES IF ANY OF THE FOLLOWING IS TRUE (1) C4 BETWEEN 1.6 AND 1.8 VAC (2) B4 > 1.6 VAC IF C4 < 1.6 VAC (3) B4 < 1.8 VAC IF C4 > 1.6 VAC
4A1A6-TP5	MBC LOCKUP	> -22V
4A1A5J1: A8	DOPPLER IF	800 HZ P-P (OSCILLOSCOPE)
4A1J4-10	ADJUSTED MAIN BEAM CLUTTER	DYM REQUIRED 1.91 TO 4.11V
4A1P1-12	SIG SEL 3 (E3)	< +1

TEST POINT	SIGNAL	VALUE
4A1P1-13	SIG SEL 3 (E3)	< +1
4A1P1-14	SIG SEL 4 (E4)	> -22V
4A3A4P1: A4	2 MD LO CONTROL SIGNAL	EXTENDER REQUIRED DYM REQUIRED 5.30 TO 5.50V (NOTE 1)
4A3J4-8	PREDICTED MBC	DYM REQUIRED 3.8 TO 4.1V
4A3J5-8	2 MD LO	COUNTER REQUIRED (8.753995 TO 30.353995 MC (NOTE 1)
6A1P1-7	APT 30.30 (AT)	> -22V
16J7-10	MBC LOCKUP	< -22V
15J5-19	1A2B1: B3	DYM REQUIRED 0.55 TO 0.65V
15J5-30	1A2B1: B1	DYM REQUIRED < 0.5 VAC
15J5-46/49	1A2B2: B1 : 1A2B2: B4	DYM REQUIRED 0.30 TO 0.30 VAC
15P1-6 15P2-7	ROLL & PITCH 30 (A30 : A31)	> -22V
15P1-PP	WIND ZERO (AT)	> -22V
15P2-A 16J5-10	V_{dc} V_{ac}	10 VAC 400 CPS 5 VAC 400 CPS
16P3-L	CMPTR TEST INPUT 5 (A1 : A31)	> -22V

NOTE
1. DISCONNECT 2A3A1P5 TO PREVENT CLUTTER LOCK FOR THIS MEASUREMENT

Figure 9b. Enriched hybrid JPA candidate (deductive element).

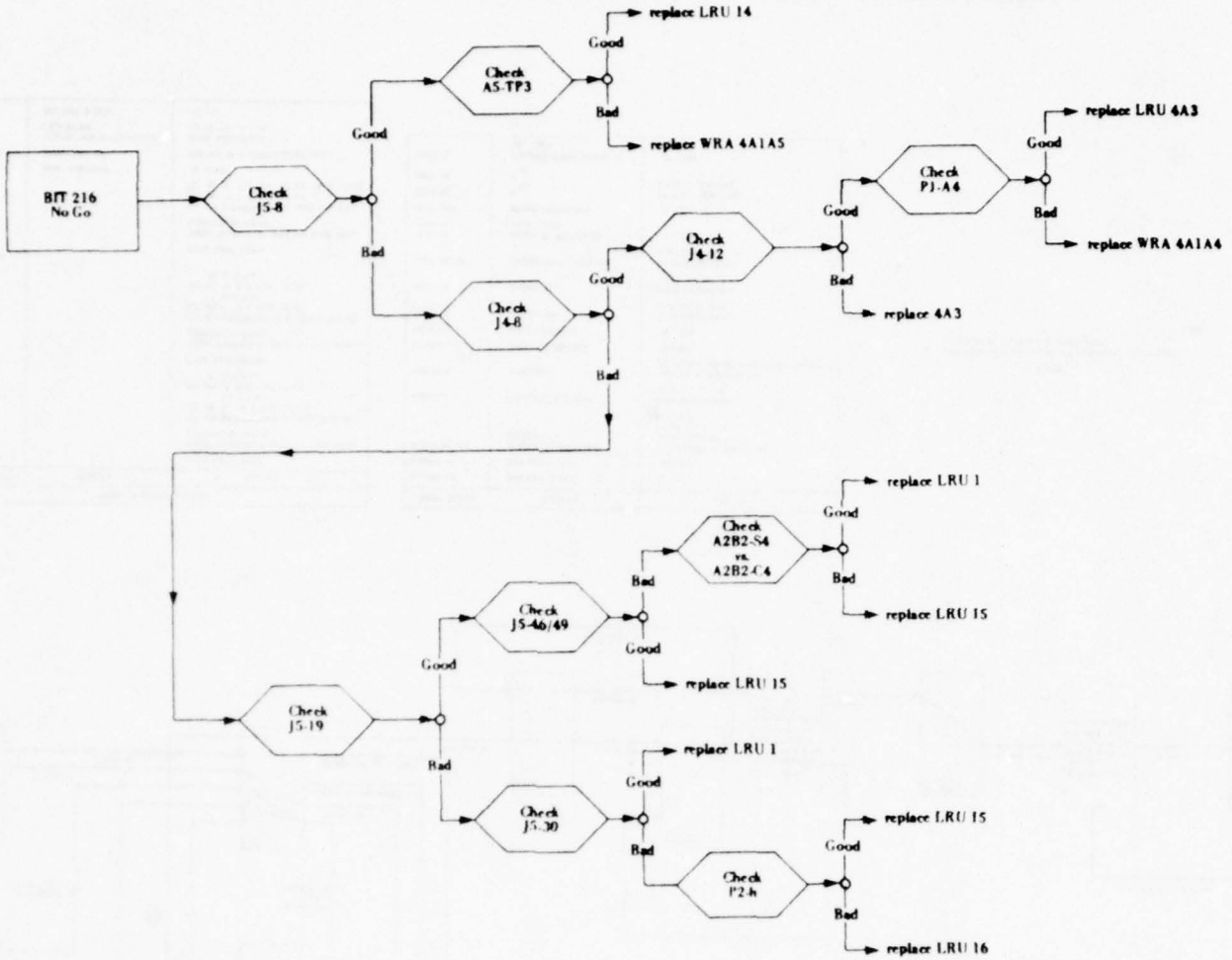


Figure 10a. PPJPA → MDC hybrid candidate (directive element).

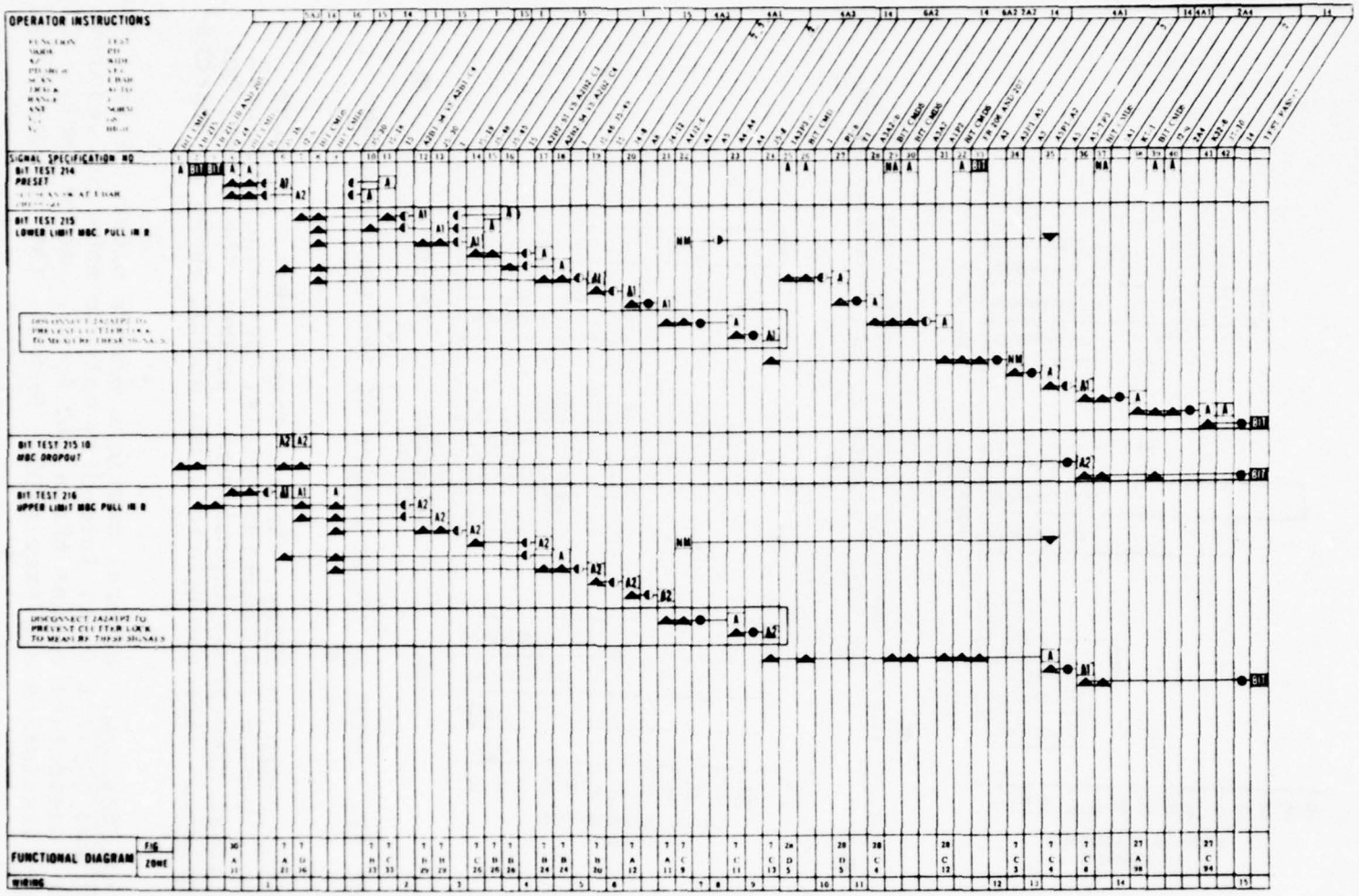


Figure 10b. PPJPA → MDC hybrid candidate (deductive element).

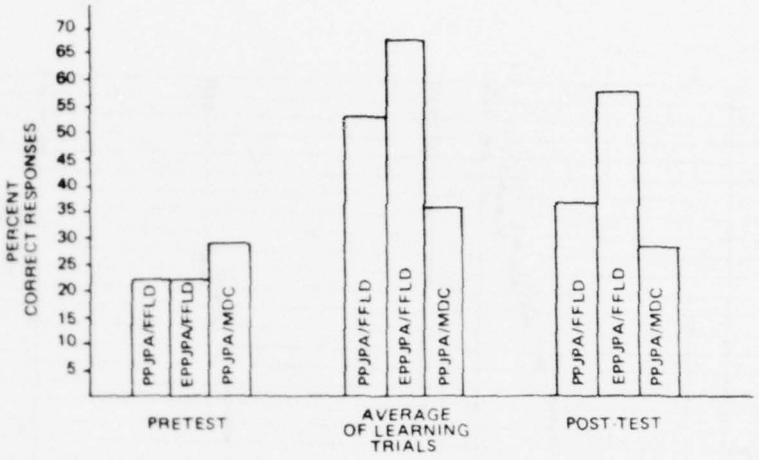


Figure 11. Percent of correct responses at three stages of the test sequence.

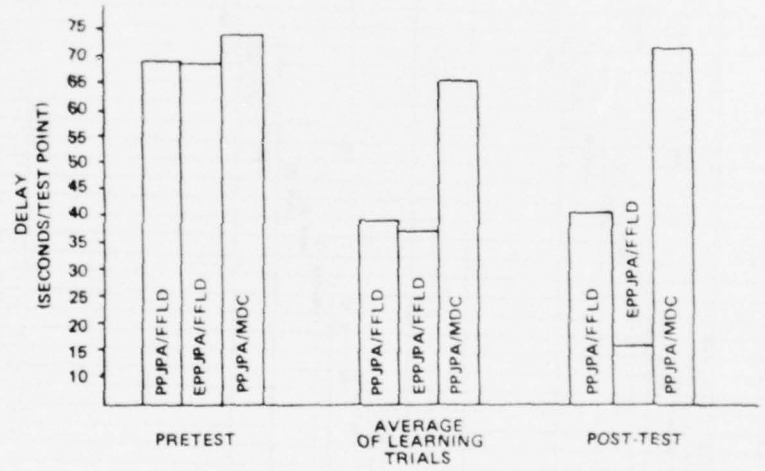


Figure 12. Delay at three stages of the test sequence.

With regard to delay, all aid forms start with near equivalency. During the learning trials, the enriched hybrid with functional flow shows improvement (as does the unenriched hybrid) while the straight hybrid using an MDC shows no improvement.

Implications. Several cautions are in order. First, the experiment was a pilot test, intending only to show the relative promise or feasibility of the three aid forms. Accordingly, only descriptive statistics are presented. Second, the comparability

of subjects can be questioned. In this regard, however, it should be noted that the use of BioTechnology personnel, because of their relatively higher level of education, should have given the unenriched hybrid using MDC an advantage over the other two conditions.

The findings are only suggestive implications, but even at this level of inference, the conclusions are provocative. Specifically:

1. Hybridization alone has a beneficial effect on performance.

2. The hybrid transitioning to an MDC is the least productive of the aids tested.

3. The enrichment concept, at least at this transition level, seems to offer promise.

Evaluation of EHJPA Candidates

Two subjective evaluations were made of the nine EHJPA candidates. In the first, six JPA research experts were asked to rate the nine candidates, knowing that those receiving low ratings were to be eliminated. In the second, three former military technicians were asked to perform a similar evaluation. The procedures, criteria, and results of these evaluations are described below.

Procedures

Raters. As indicated above, the evaluation employed two sets of raters. The individuals in the set of six raters were chosen because they are putative experts in the field of job performance aiding. Those in the set of three raters were chosen because of their experience in using and supervising the use of job aids in the field.

Criteria for Rating. Three criteria were considered in rating the nine EHJPA candidates. The most important was volition, which refers to (1) the likelihood that a user would voluntarily avail himself of the enrichment information, and (2) given that the user does avail himself of the enrichment message, whether he would consider the effort worthwhile.

The second criterion was labeled expected work output. The issue in question was whether the particular enrichment strategy might tend to impair timely and accurate completion of the immediate task. Over an entire action sequence, the effect of enrichment could be to produce a noticeable delay in task completion. Even worse, the enrichment information could be a distraction to the user. If that were the case, more errors might be committed.

The third criterion was the expected level of learning for the information provided via a given enrichment strategy.

Rating Scales. For each of the criteria, a rating scale was developed that consisted of two subscales. For volition, the subscales were probability of exposure and reward value. Probability of exposure means the likelihood that the technician will read or study the message. Reward value refers to a conceptual cluster of possible reinforcements that range from the satisfaction of understanding the purpose behind the task being performed to the sense of personal effectiveness that is associated with doing the task well. Among the cluster of possible reinforcements, however, the most crucial one for rating purposes should be whether--or the probability that--the enrichment is judged to contribute to the feeling of independence or autonomy on the part of the technician in the task situation.

For expected work output, the subscales were time (i.e., expected delay) and error rate. Reading the enrichment message takes some time that might otherwise be used in direct work on the task. Consequently, some delay is built in. The issue is how much delay, as well as whether any recapture of time is likely due to the technician's enhanced confidence or other positive contribution from the enrichment messages. Concern for error rate is based on the possibility that the enrichment message could act as a distractor in breaking the technician's concentration on the task at hand. One assumption is that, if the technician's attention is diverted, some increase in probability of error will occur.

The two subscales for expected level of learning were the amount or quality of task/career relevant material learned and retention over time. If the enrichment information is meaningful to the technician's career or to the task at hand, then the degree to which the information is used would be a valid means of rating EHJPAs. Assessing the technician's retention of the information would be another method of determining the usefulness of an EHJPA.

Expert Rating. The six experts in the first set of raters were briefed on the nature of the enrichment strategies and the rating criteria. Each expert was given a briefing book that contained either a concrete example or a written description of each candidate enrichment strategy.

After hearing the briefing, discussing ambiguities, and examining the examples, the raters were asked to independently complete rating forms that corresponded to each of the subscales. These forms were an integral part of the briefing book. An example of such a form is presented in Figure 13.

Form A-1

Probability of Exposure to Enrichment Message

Enrichment Strategy		Indicate on the scales below your estimate of the probability that the typical technician will read/study the enrichment message
Enrichment Type	Message Format	
Transition	Interpretive	0 .25 .50 .75 1.00
	Basic Reference Cues	0 .25 .50 .75 1.00
	Extension Training Reference Cues	0 .25 .50 .75 1.00
System Understanding	Interpretive	0 .25 .50 .75 1.00
	Basic Reference Cues	0 .25 .50 .75 1.00
	Extension Training Reference Cues	0 .25 .50 .75 1.00
Theory	Interpretive	0 .25 .50 .75 1.00
	Basic Reference Cues	0 .25 .50 .75 1.00
	Extension Training Reference Cues	0 .25 .50 .75 1.00

Figure 13. Sample of rating forms.

One week after the six experts made their initial rating, a second meeting was convened to review the results and discuss the differences between raters. As might be expected, the discussion revealed some variation between judges in their interpretation of certain criteria and their assumptions about how the EHJPAs might be used.

The discussion was structured by taking each scale in turn and identifying anomalies--if any--in the ratings assigned to each candidate. The rationale for any anomalous rating was elicited and discussed in such a way that all raters understood the reasoning behind the anomalous rating(s). Following this discussion, the experts were asked to rerate the candidate EHJPA options.

User Rating. As suggested above, the procedure was much the same for the users as for the experts. Due to a limitation of time, however, only one rating session was held and only four of the six subscales were used. These four subscales--volition, time, error, and learning--were considered as providing the most relevant information.

The three users were briefed as a group and given the briefing book containing examples/descriptions of the job aid materials for each enrichment strategy. Ambiguities regarding concept, criteria, or scales were resolved in open discussion.

Results

Tables 5 and 6 present the average ratings given to each of the nine EHJPA candidates by the experts and the users. These data were used in a candidate evaluation designed to select enrichment candidates for additional testing. The evaluation was conducted in two steps described below.

Step 1: Top Three Candidates. The user and expert ratings for a given strategy and a given scale were examined to see whether that strategy was among the top three. For example, Figure 14, which provides the A-1 rating of the users for all nine enrichment strategies, shows that candidates 1, 5, and 7 received the three highest ratings. Performing this analysis on all the subscales in the user/expert ratings yields the results shown in Figure 15. Candidates 1, 5, 7, and 9 accumulated the most "hits" (four or greater) in this assessment; accordingly, they are considered for additional testing at this stage of the evaluation.

Table 5

Experts' Ratings on Each Scale

	Interpretive		Basic Reference Cues		Extension Training Reference Cues	
	①		②		③	
TRANSITION	A-1	8.6	A-1	5.4	A-1	3.5
	A-2	6.9	A-2	5.0	A-2	4.3
	B-1	5.3	B-1	4.0	B-1	6.7
	B-2	6.2	B-2	4.1	B-2	4.1
	C-1	7.1	C-1	5.2	C-1	5.3
	C-2	5.9	C-2	5.2	C-2	6.1
	④		⑤		⑥	
SYSTEM UNDERSTANDING	A-1	7.2	A-1	5.8	A-1	2.9
	A-2	6.3	A-2	6.2	A-2	3.6
	B-1	4.3	B-1	3.8	B-1	6.2
	B-2	4.4	B-2	5.4	B-2	5.1
	C-1	4.5	C-1	5.5	C-1	5.5
	C-2	5.4	C-2	4.6	C-2	7.1
	⑦		⑧		⑨	
THEORY	A-1	6.2	A-1	3.8	A-1	2.6
	A-2	4.2	A-2	3.6	A-2	5.0
	B-1	4.1	B-1	4.5	B-1	6.2
	B-2	4.6	B-2	4.7	B-2	6.2
	C-1	2.8	C-1	3.1	C-1	6.0
	C-2	3.1	C-2	2.3	C-2	5.3

SCALES

A1 = Volition
A2 = Reward
B1 = Time
B2 = Error
C1 = Learning
C2 = Retention

Table 6

Users' Ratings on Each Scale

	Interpretive	Basic Reference Cues	Extension Training Reference Cues
TRANSITION	①	②	③
	A-1 6.8	A-1 3.7	A-1 1.2
	B-1 4.7	B-1 2.5	B-1 1.0
	B-2 1.0	B-2 2.2	B-2 2.8
	C-1 4.7	C-1 2.7	C-1 2.2
SYSTEM UNDERSTANDING	④	⑤	⑥
	A-1 5.5	A-1 7.2	A-1 3.5
	B-1 6.5	B-1 5.0	B-1 3.8
	C-2 4.8	B-2 5.5	B-2 6.2
	C-1 3.3	C-1 5.2	C-1 4.0
THEORY	⑦	⑧	⑨
	A-1 6.5	A-1 5.7	A-1 5.0
	B-1 7.7	B-1 7.0	B-1 6.7
	B-2 6.8	B-2 7.5	B-2 7.2
	C-1 7.3	C-1 7.7	C-1 8.0

SCALES

A1 = Volition
B1 = Time
B2 = Error
C1 = Learning

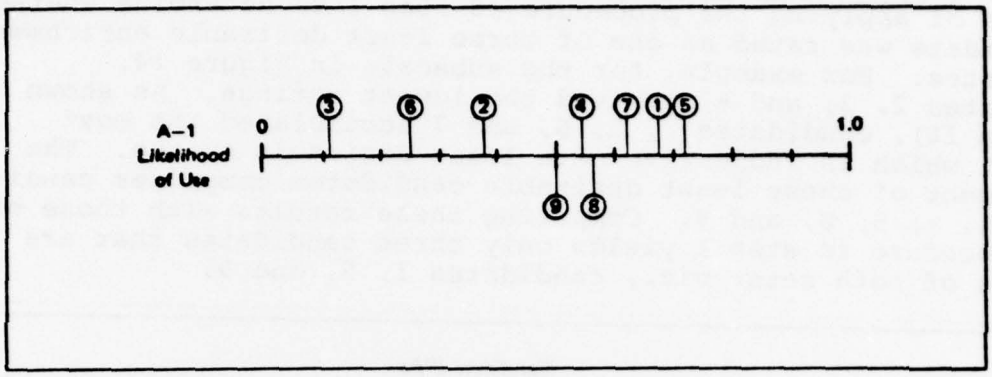


Figure 14. Distribution of ratings on A-1, likelihood of use scale.

		Candidate JPAs								
		1	2	3	4	5	6	7	8	9
EXPERT RATINGS	A-1	✓			✓			✓		
	A-2	✓			✓	✓				
	B-1			✓			✓			✓
	B-2	✓				✓				✓
	C-1	✓				✓	✓			✓
	C-2	✓		✓			✓			
USER RATINGS	A-1	✓				✓		✓		
	B-1							✓	✓	✓
	B-2							✓	✓	✓
	C-1							✓	✓	✓
	Totals	6	0	2	2	4	3	5	3	6

Figure 15. Top three candidates.

Step 2: Lowest Three Candidates. Figure 16 shows the results of applying the procedure of step 1 to determine whether a candidate was rated as one of three least desirable enrichment candidates. For example, for the subscale in Figure 14, candidates 2, 3, and 6 received the lowest ratings. As shown (Figure 16), candidates 2, 3, 6, and 7 accumulated the most "hits," which is indicative of a least-desirable status. The complement of these least desirable candidates comprises candidates 1, 4, 5, 8, and 9. Comparing these results with those of the procedure in step 1 yields only three candidates that are members of both sets; viz., candidates 1, 5, and 9.

		Candidate JPAs								
		1	2	3	4	5	6	7	8	9
EXPERT RATINGS	A-1			✓			✓			✓
	A-2						✓	✓	✓	
	B-1		✓			✓		✓		
	B-2		✓	✓	✓					
	C-1				✓			✓	✓	
	C-2					✓		✓	✓	
USER RATINGS	A-1		✓	✓			✓			
	B-1		✓	✓			✓			
	B-2	✓	✓	✓						
	C-1		✓	✓	✓					
Totals		1	6	6	3	2	4	4	3	1

Figure 16. Bottom three candidates.

On the basis of this analysis of expert and user ratings, the following EHJPA candidates are recommended for additional testing:

1. Candidate 1: Transition--Interpretive (solid support from the expert raters).

2. Candidate 5: System Understanding--Basic Reference Cue (modest support from the expert raters).

3. Candidate 9: Theory--Extension Training Reference Cue (modest support from both the expert and user raters).

CONCLUSIONS

Hybrid JPA

Combining directive and deductive aids into a hybrid troubleshooting JPA is intended to teach naive technicians how to troubleshoot relying only on the deductive aid. The evaluation studies conducted during this project indicate that this goal is achievable. The evidence to support this contention is in the form of results of paper-and-pencil malfunction problems that subjects were asked to solve. Subjects achieved a low accuracy in their attempt to solve the initial problem supported by only a deductive aid. After several learning trials, performing with the hybrid JPA, subjects again used only the deductive aid to solve a "test problem," demonstrating considerable improvement in their accuracy scores.

Enriched Hybrid JPA

Enrichment, when used to enhance the effect of hybridization (referred to as Transition enrichment), appears feasible. The evidence to support this contention is in the form of subject performance on paper-and-pencil troubleshooting problems. Subjects performing with enriched hybrid aids learned to troubleshoot with deductive aids twice as effectively as subjects performing with identical but unenriched hybrids.

In addition, enrichment of hybrids appears feasible when it is used to convey career-relevant knowledge about the hardware at hand (called System Understanding) as well as knowledge of the principles governing classes of hardware (called Theory). Evidence to support this contention is in the form of expert and user opinion ratings of various enrichment candidates. Ratings were solicited on (1) likelihood of aid use, (2) adverse effect on task performance, and (3) learning effects.

RECOMMENDATIONS

The evidence to support the findings presented above was in the form of a pilot test (e.g., small sample size, part task representation, nonrepresentative subjects), and expert opinions of JPA research experts and JPA user experts. Prior to an extensive field test of the enriched hybrid JPA, a more rigorous demonstration of its feasibility, under more representative conditions, is required.

The hybrid and enrichmment aid concepts were delimited in the research reported here, and are expected to undergo rigorous experimentation to prove their technical feasibility. In addition, analytical work is required to define key operational considerations. These are:

1. Aid Applicability. Several aspects of the aid forms must be defined before they can be considered ready for even limited demonstration projects. For example, the Theory-Extension Training Reference Cues strategy (heavily favored by the user poll taken during this project) requires considerable work on how to gauge the user's qualifications in order to control his exposure to enrichment messages.

2. Head Book Trade-Off. The interface of all enriched JPAs with formal and extension training requires definition. This interface should cover the degree to which mastery of a particular EHJPA qualifies a user for formal schooling as well as the type of schooling required to qualify a user for a particular EHJPA.

3. IPS Interface. An objective of the IPS is to facilitate advancement along any of several career path options. The extent to which EHJPAs, individually and in combination with formal training, qualify a user for career milestones needs to be established. For example, mastery of some of the EHJPAs appears to be related to the requirements of the Personnel Qualification System; and mastery of the theory types of enrichment appears to relate to a user's preparedness to take the advancement in Rate exams. The full potential of JPAs in the IPS will not be understood until relationships such as these are identified and defined.

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